Braille-to-Print Access for Visually Impaired Science Students

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NEED

Recent years have seen the advent of electronic techniques for the production of braille for blind students. When combined with optical scanners, modern software such as the Duxbury Braille Translator for Windows allows braille documents to be created from print originals quickly, efficiently, and with little formal training. Sadly, the reverse is not true; that is, the only viable technique for converting existing hard-copy braille into print is for a skilled transcriber to reverse translate the document. In other words, a human being must perform the task of examining each dot pattern (or *cell*) and translating that cell into its print equivalent. As will be explained, this is a complex task, involving many decisions, but not entirely impossible to automate.

The lack of a reverse braille translator is the source of two major problems in science education today. The first problem is obvious; namely, blind students who have completed their homework in their natural literary medium (braille) must somehow get that information translated into the natural literary medium of the instructor or grader (print). Current solutions to this problem either involve a human translator (which is expensive and not fast enough for most applications) or the verbal transcription of the document. This verbal transcription process involves the blind student reading the brailled material out loud to a sighted proctor, who then records the information in print. This process is the one currently used by the VISIONS Lab at Purdue and other institutions such as the MAVIS project at New Mexico State University. This technique, although the most common, also has several disadvantages. First, this process often introduces transcription errors, which can result in incorrect answers on tests or homework. Second, some concepts are difficult to express verbally, such as complex mathematical equations or chemical reactions. This is a very real problem especially for blind math students, as the working of math problems invariably requires the interactive use of braille, but the teacher requires a print answer.

The second problem caused by the lack of an automated braille-to-print translator is the conversion of existing braille books. Many existing braille production houses have braille-only copies of books, or non-electronic master copies of the books that have fallen into disrepair. For example, the American Printing House for the Blind has thousands of metal master plates for various braille books. These master copies are usable only for large print runs (it is significantly more expensive to run fewer than 10 copies using the metal plate-braille press system than to computer-generated embossing) and thus many books are not available for printing for the students that need them. Also, some of the plates have deteriorated over multiple uses so that while the dot image is still visible, the relief is not sufficient to create proper braille when used in the press. Finally, some of the books archived in printing houses and libraries exist only as hand-transcribed documents and have no master, electronic or otherwise. For these types of documents, the only recourse is to laboriously hand-code the braille dot patterns cell-by-cell into

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DESCRIPTION OF ACTIVITIES

The VISIONS Lab's plan is to develop software algorithms that will eli[illegible] for manual reverse translation of hard-copy braille. This project will involve [illegible] several major organizations involved with braille production, and will result [illegible] available product distributed worldwide. This project is based on prior proof-of-[illegible] done by the VISIONS Lab and relies heavily on expertise that the VISIONS L[illegible] during its [illegible] to blind stud[illegible]

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The second phase will involve the conversion of the electronic file (in ASC[illegible] an actual print document. This will involve the collaboration of Duxbury Systems, [illegible] has already developed ASCII braille-to-print software for literary braille. The VISIO[illegible] together with Duxbury, will create ASCII braille-to-print math software to n[illegible] code (the current standard for producing braille math). This software will ba[illegible] the award-winning VISIONS Lab print equation-to-Nemeth translator already inco[illegible] into Duxbury's standard math transcription package.

The final phase will be the testing and dissemination phase. It is crucial that [illegible] result be proven at leas[illegible] and match [illegible] VISIONS Lab will collaborate with the American Printing House for the Blind to reverse translate some of the more difficult braille books, in some cases comparing the resultant prin[illegible] a simultaneous reverse translation using established techniques. The dissemination of the [illegible] product will be in two forms. First, the basic version of the software will be made available [illegible] Duxbury as part of their existing braille translation software in an economical fashion [illegible] software will be meant for small-scale translation by the individual student or school. Second, and enhanced version of the software will be released for large printing ho[illegible] software will contain additional features meant for enhancing large-scale translat[illegible] other [illegible] but will be more expensive, and geared mainly towards these inst[illegible] needing to update or eliminate their large existing stores of braille-only or [illegible]

METHOD

an electronic master copy. However, if the master existed in electronic format, the relatively inexpensive process of computer-controlled embossing could be utilized to print a small number of copies.

Thus, a strong need for an automated system of translating braille to print exists. Such a technique would allow blind students to independently create print documents from their braille originals with relatively few errors and at a useful speed. This would eliminate the problems faced by blind math and science students in working homework problems and tests. Additionally, such a system would allow countless braille-only documents to be reprinted or printed in low volume, an advancement that would dramatically increase the number ad variety of books available to blind science, engineering, and math students.

DESCRIPTION OF ACTIVITIES

The VISIONS Lab's plan is to develop software algorithms that will eliminate the need for manual reverse translation of hard-copy braille. This project will involve the collaboration of several major organizations involved with braille production, and will result in a commercially available product distributed worldwide. This project is based on prior proof-of-principle work done by the VISIONS Lab and relies heavily on expertise that the VISIONS Lab has gained during its years of service to blind students.

First, the VISIONS Lab will modify existing image-processing software developed by the VISIONS programming staff for the automatic conversion of color images into tactile graphics. This software will be turned into "braille OCR" (Optical Character Recognition) software, and has already been demonstrated to be feasible for the task by work previously done by the VISIONS Lab. The end result of this phase will be a Windows-based program that will automatically convert scanned or photocopied and then scanned braille into an electronic file.

The second phase will involve the conversion of the electronic file (in ASCII format) into an actual print document. This will involve the collaboration of Duxbury Systems, Inc., which has already developed ASCII braille-to-print software for literary braille. The VISIONS Lab, together with Duxbury, will create ASCII braille-to-print math software to handle Nemeth braille code (the current standard for producing braille math). This software will basically be a reversal of the award-winning VISIONS Lab print equation-to-Nemeth translator already incorporated into Duxbury's standard math transcription package.

The final phase will be the testing and dissemination phase. It is crucial that the end result be proven at least as accurate and much faster than human translation. To this end, the VISIONS Lab will collaborate with the American Printing House for the Blind to reverse translate some of the more difficult braille books, in some cases comparing the resultant print to a simultaneous reverse translation using established techniques. The dissemination of the final product will be in two forms. First, the basic version of the software will be made available through Duxbury as a part of their existing braille translation software, in an economical fashion. This software will be meant for small-scale translation by the individual student or school. Second, and enhanced version of the software will be released for large printing houses. This software will contain additional features meant for enhancing large-scale translation of books and other documents, but will be more expensive, and geared mainly towards those institutions needing to update or eliminate their large existing stores of braille-only or plate-only documents.

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Phase one of the project involves the creation of "braille OCR" software for converting braille to print. The most important part of this phase is the development of accurate image recognition techniques to interpret individual dot patterns as braille symbols. This can further be divided into three main stages: acquiring the image, processing the image, and creating the output file.

Image acquisition is a nontrivial operation, since most braille books are 11" by 11.5", and thus too large for most flatbed scanners. VISIONS Lab testing has found that scanning the braille with strong backlighting or first photocopying the braille with high contrast and then scanning is sufficient to produce a reliable electronic image for processing. Most student homework is done on 8.5" by 11" paper (using a Perkins brailler or stale-and-stylus) and thus may be directly scanned. For larger documents (such as books), the braille must first be photocopied and reduced to 77% of original size. Since this shrunken braille maintains the same aspect ratio, but comes nowhere near to the resolution limit (300 dpi or more) of modern scanners, books and other large documents can be made to fit a scanner using this technique. Other nonstandard image acquisition techniques used in "normal" OCR such as digital cameras apply for braille OCR as well.

After the image is acquired, it must be processed. This relies heavily on noise filtering and pixel classification techniques developed by the VISIONS Lab for other purposes. The existing software will be modified to process the braille dots in three steps. First, the scanned image will be "cleaned up" using image processing techniques. Second, the document will be divided into "cell zones", with each zone outlining the exact dimensions of that braille cell, so that all of the 6 possible dots fall within the zone. This may require some user input to determine top-of-page, etc. in the initial version. At this time, the computer will make the binary decision as to whether each dot of the cell is raised or not raised. This will again require the use of traditional image processing techniques.

Finally, an output file will be created, with each cell on the page being assigned an ASCII character based on the standard ASCII braille table. This will be done by relying on a simple lookup table that will match the output of the processing step (an eight-digit binary number for each cell) with its corresponding ASCII equivalent. This stage may require some user input as well, as it is helpful to know whether the scanned braille was a French textbook, a literary English history book, or a Calculus book in Nemeth. This user-defined information will be placed in the file header in such a fashion as to be accessible to the Duxbury translation software.

Phase two involves the conversion of the electronic file into an actual print document. This will involve three main steps. First, the VISIONS lab programming staff will work closely with Duxbury to ensure that the ASCII output file can be properly interpreted by their software. Second, provision must be made for the reverse translators that do no yet exist such as the Nemeth reverse translator. Finally, the program must be developed into a viable standalone product that integrates seamlessly with existing graphics programs and braille translation software.

First, the ASCII output must be readable as a *.DXB file by the Duxbury software. This will involve the placing of codes at the head and in the body of the ASCII file to tell the braille translator about the type of braille, the formatting, and any other important information. If, for example, the header title of a new document section was expressed by a centered braille title in all caps, separated by blank lines before and after, then this should be faithfully represented in print as a section header, and thus the ASCII file must contain information that tells the Duxbury

software to treat that header as a header and not as body text. However, this is a straightforward (albeit tedious) process.

Second, the reverse Nemeth translator (and perhaps some reverse translators for the major foreign languages, time permitting) must be created as well. Since the VISIONS Lab has already developed the first print equation-to-Nemeth braille translator, it will be an easier task to create a Nemeth braille-to-print translator. Although the base program will be radically different both in logic and coding, the rules, tools, and tricks that the VISIONS programming staff developed in creating the forward translator will still apply. This software will be incorporated into the Duxbury suite just as the forward translator already has been.

Finally, the software must be formed into a professional-quality product. This will involve user interface design and the creation of option and customization features. At this time the separation of product into the basic version and the printing-house version will be made. For example, the printing house version may contain options for continuos translation of a book, where every page is the same in format and style except for the first pages in the chapter, which have special formatting. Another example is the reverse translation of indices or tables, a feature that would probably be part of the deluxe version and not a basic feature. The basic version would contain all that the individual student would need to translate exams and/or homework, however. This would likely be packaged by Duxbury as a value-added item as they currently do with Corel® WordPerfect® Suite and the Purdue Nemeth translator.

The final phase involves the dissemination and testing of results. Of course, testing will be a part of the project from the beginning. For example, the initial converter will be tested for accuracy by comparing carefully hand-translated documents with the output of the software using a file compare utility. This data will help to determine the level to which field testing will be done for the final product, as discussed below. Dissemination will mainly take place through Duxbury Systems, Inc.

For the basic version, beta testing will be conducted at several universities around the country, such as Purdue's VISIONS Lab and New Mexico State's MAVIS project. Volunteer students enrolled in math or science courses will use the software in addition to their normal techniques, and provide feedback on making the software better. Statistics will be compiled to ensure that minimum accuracy levels and proper documentation are an integral part of the software.

For the deluxe version, large-scale testing will be done at the American Printing House for the Blind. Several Nemeth and literary braille documents will be simultaneously reverse translated using the experimental software and traditional techniques and the results compared. In addition, testing with the metal plates will be extensive, to ensure that the end product can actually help printing houses to reduce the inventory of metal printing plates.

DISSEMINATION

The final products will be released commercially by Duxbury Systems, Inc. with full documentation. In addition, both in the testing process and after completion of the project, the help of students and organizations around the country will be sought, relying heavily on World Wide Web-based organizations such as EASI (Equal Access to Software and information). Finally, a report describing the process and how to use the software will be released to print and electronic journals so that students around the country can benefit from the results.

BUDGET SUMMARY

This will be a three-phase project, with each phase requiring one year for completion:

PHASE I			
	EQUIPMENT:	high-end flatbed scanner	$2,000
		software	$8,000
	SUPPLIES:	office, media, miscellaneous	$5,000
	PERSONNEL:	Director (30% FTE)	$40,000
		Grad. Assistants (50% FTE each)	$60,000
		Programmer (50% FTE)	$75,000
		Blind Research Assistant (50% FTE)	$10,000
	TOTAL:		***$200,000***
PHASE II			
	EQUIPMENT:	software	$5,000
	SUPPLIES:	miscellaneous	$5,000
	PERSONNEL:	Director (30% FTE)	$40,000
		Grad. Assistants (50% FTE each)	$60,000
		Programmer (50% FTE)	$75,000
		Blind Research Assistant (50% FTE)	$10,000
	SUBAWARDS:	Duxbury Systems (consulting)	$5,000
	TOTAL:		***$200,000***
PHASE III			
	EQUIPMENT:	software	$5,000
	SUPPLIES:	miscellaneous	$5,000
	PERSONNEL:	Director (30% FTE)	$40,000
		Grad. Assistants (50% FTE each)	$60,000
		Programmer (50% FTE)	$75,000
		Blind Research Assistant (50% FTE)	$10,000
	SUBAWARDS:	American Printing House (consulting)	$5,000
	TOTAL:		***$200,000***